Local & Regional Energy Estimates from Coda-Derived Moment-Rate Spectra

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The measurement of radiated seismic energy of small-to-moderate sized events is complicated by small scale-length heterogeneities and site response which are usually ignored when studying large magnitude events. We report on results using an empirical approach that takes advantage of the stochastic, averaging nature of coda waves.

Example of stable, coda-derived moment-rate source spectra at seven BDSN stations.

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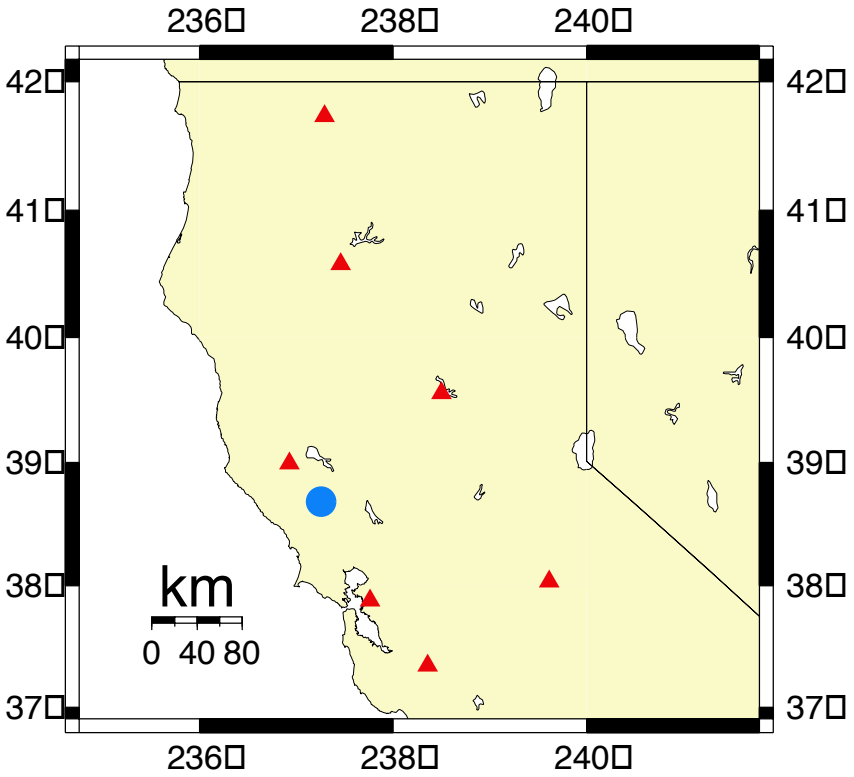
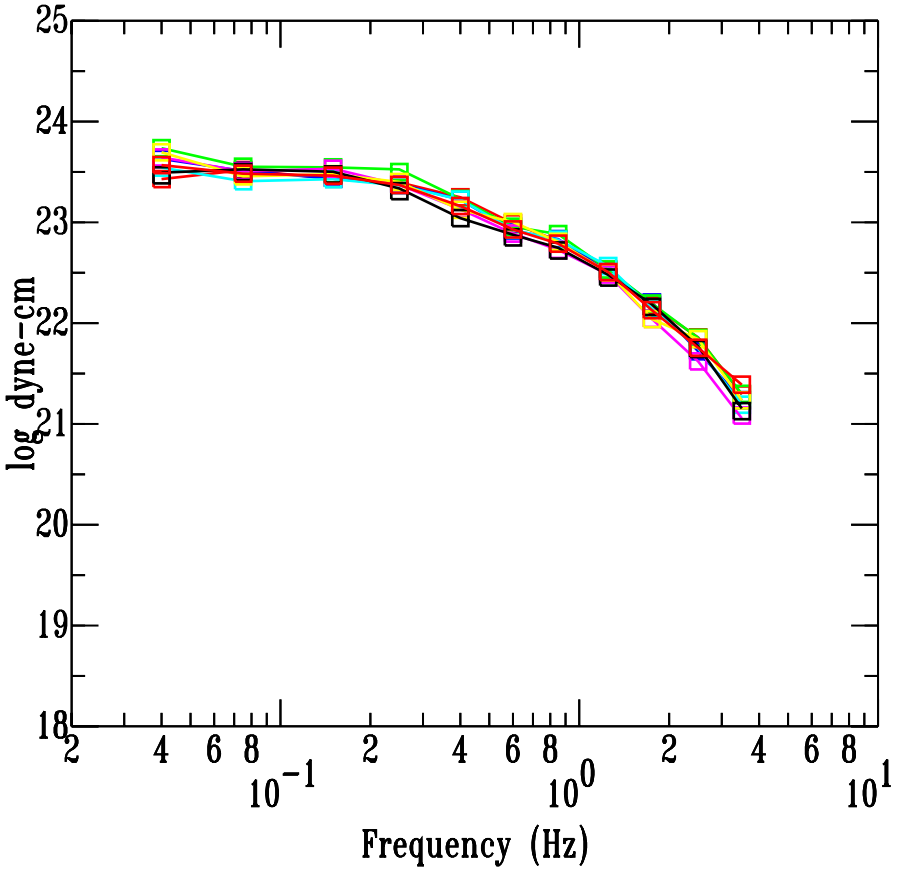
Event 952471414 M_w 4.9



Moment-rate Spectra



Note: We have assumed the same homogeneous, frequency-dependent model for all of northern California. Only station-dependent site effect corrections were applied.

Other examples of stable, coda-derived moment- rate source spectra.

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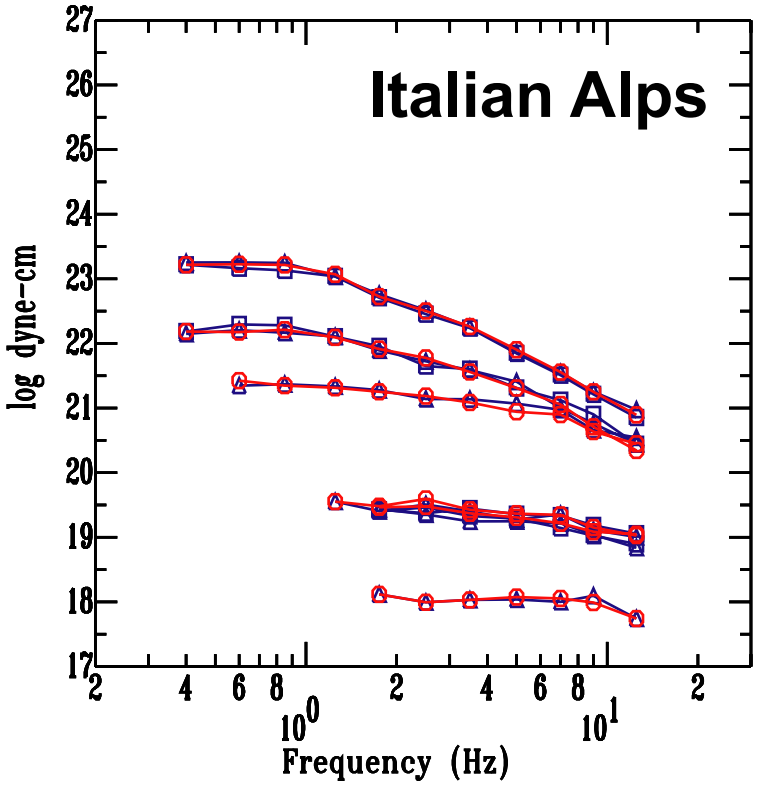

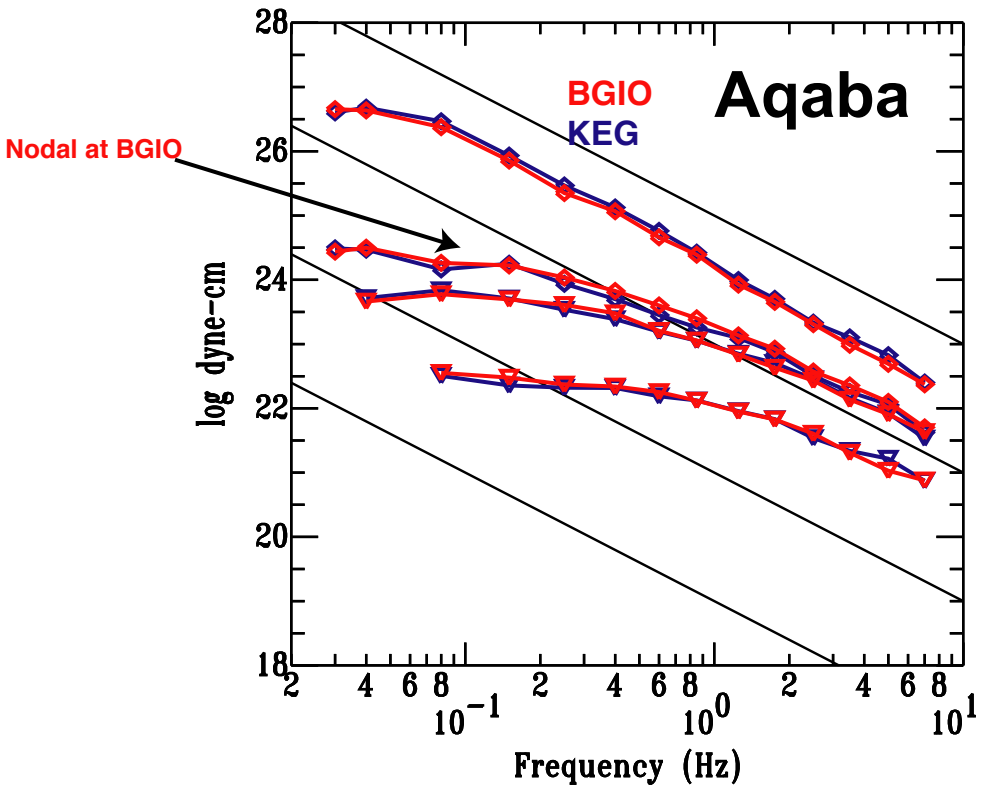

M_W and E_R estimates from coda-derived moment-rate spectra exhibit unprecedented stability.

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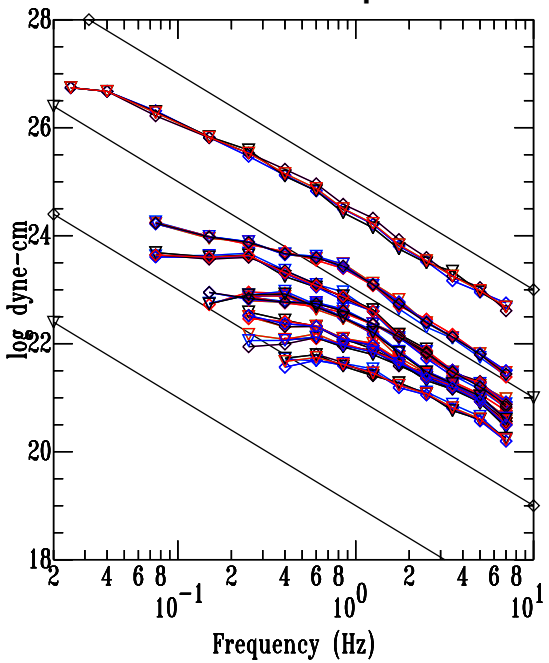
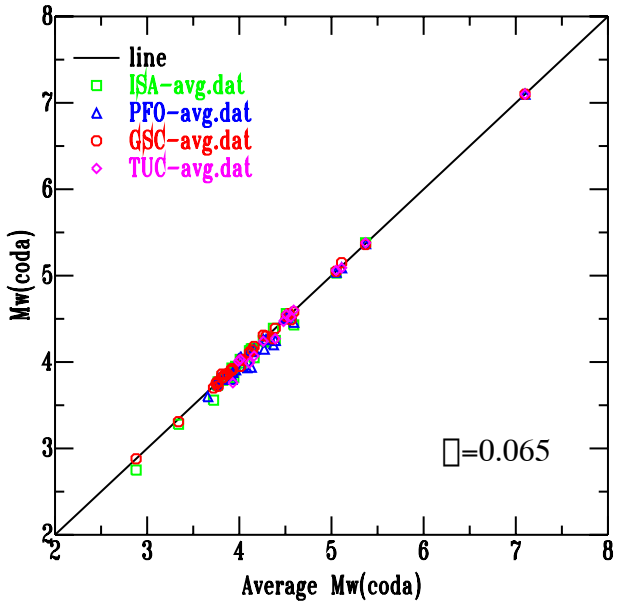
Hector Mine

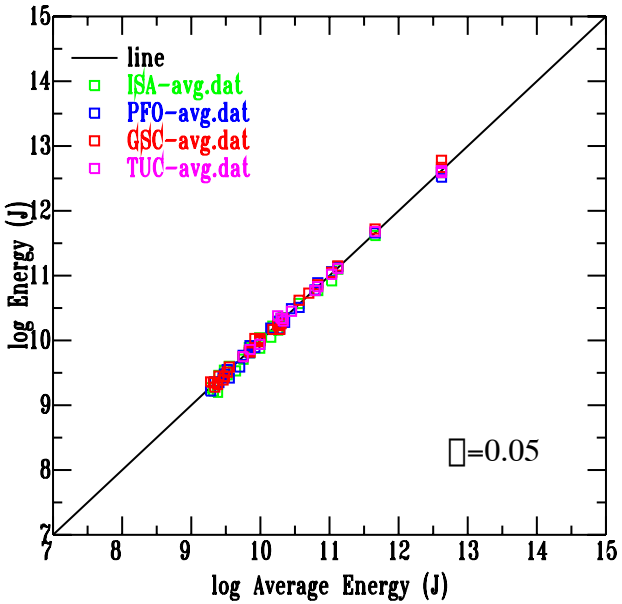
Moment-rate Spectra



Moment-magnitudes



Radiated Energy



Moment-rate spectra were validated with independent M_W's and then used to estimate the total radiated seismic energy.

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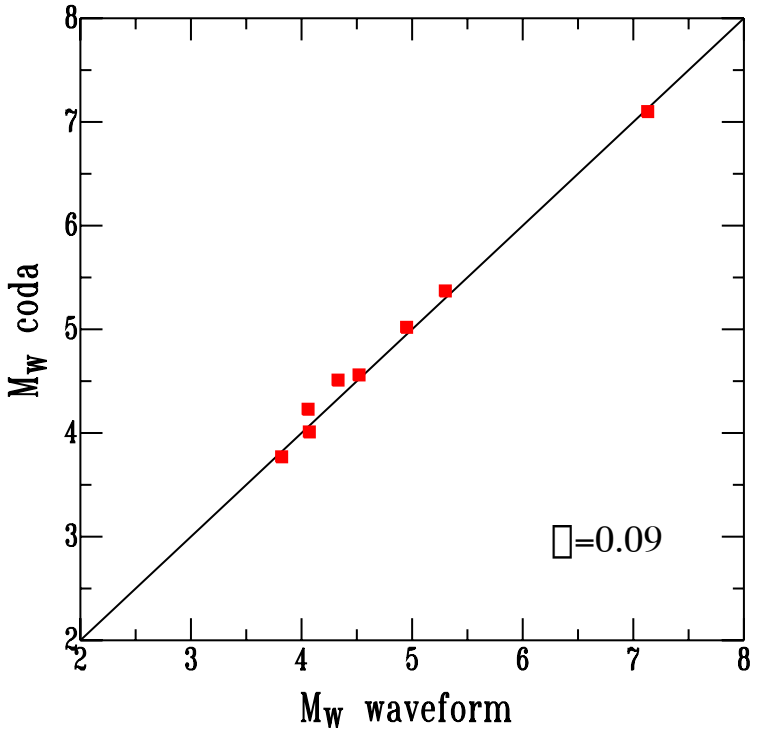
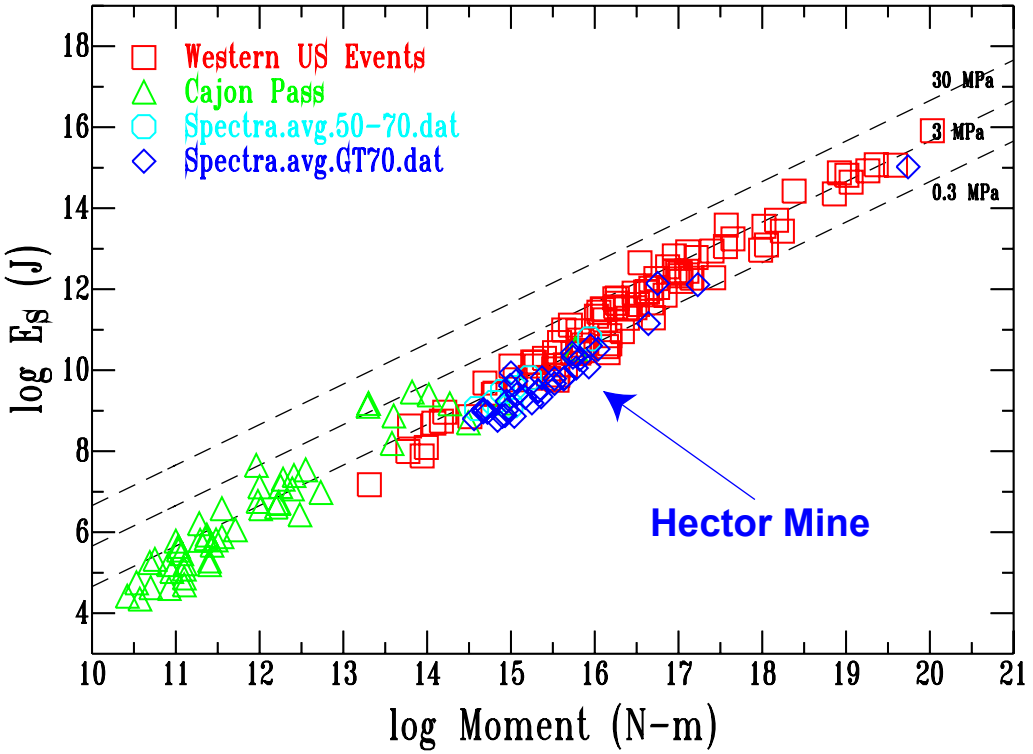
Moment-magnitudes



(from J. Polet & G. Ichinose)

Total Radiated Energy vs Moment



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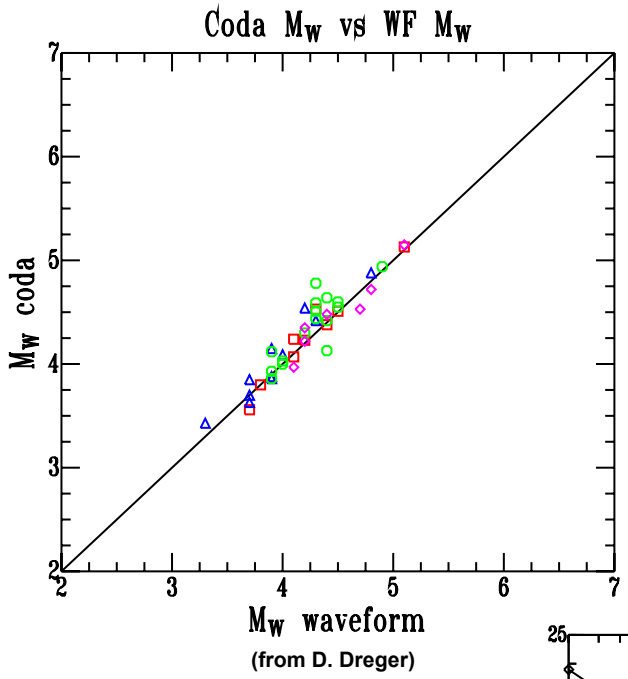

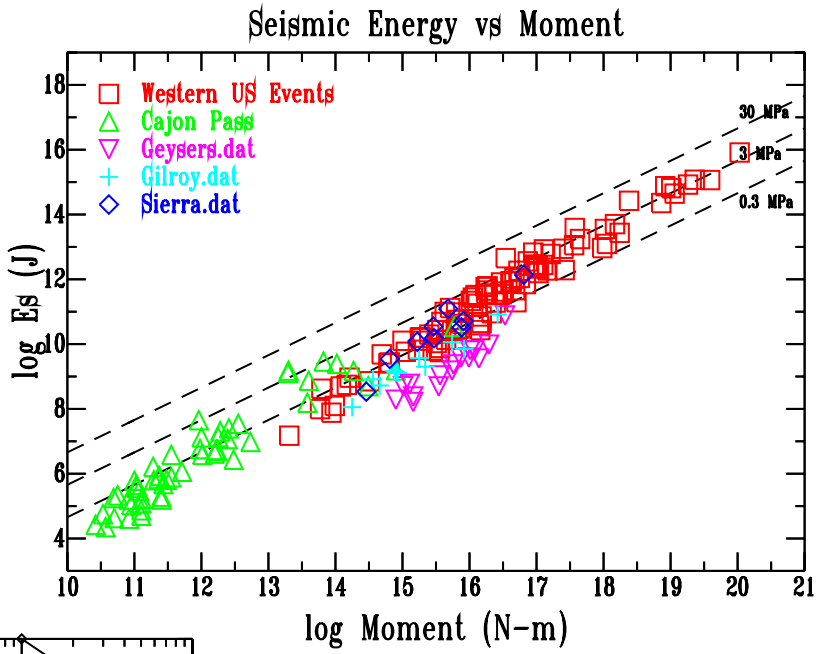

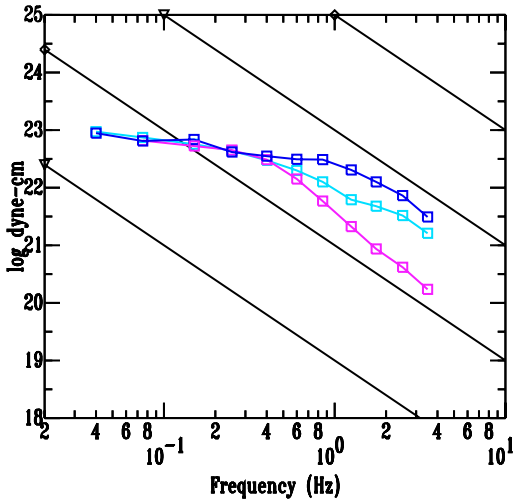

Note: We find that Geysers events exhibit low E_R/M_O ratios compared to Sierra and Hollister/Gilroy events.

Many regions in the world appear to exhibit non-constant stress drop scaling.

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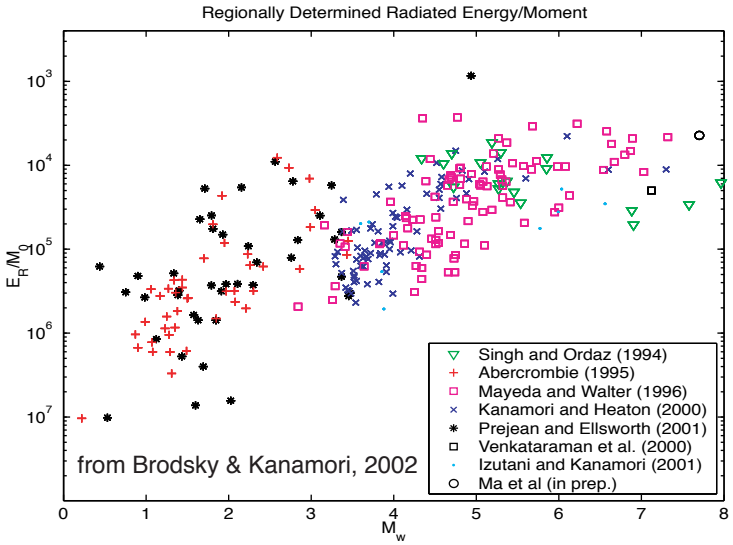

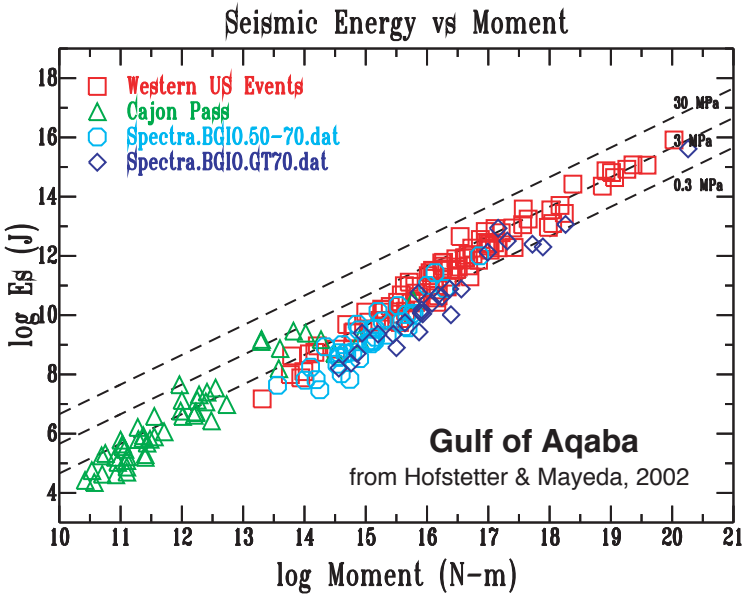

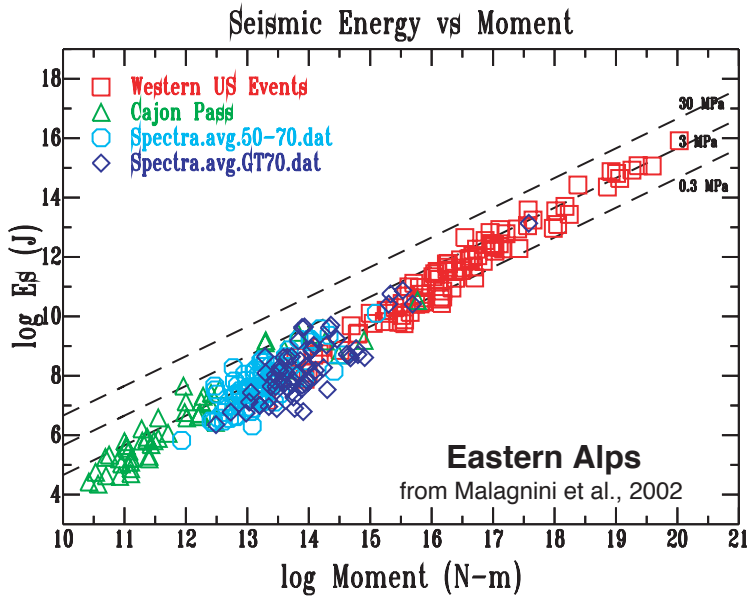

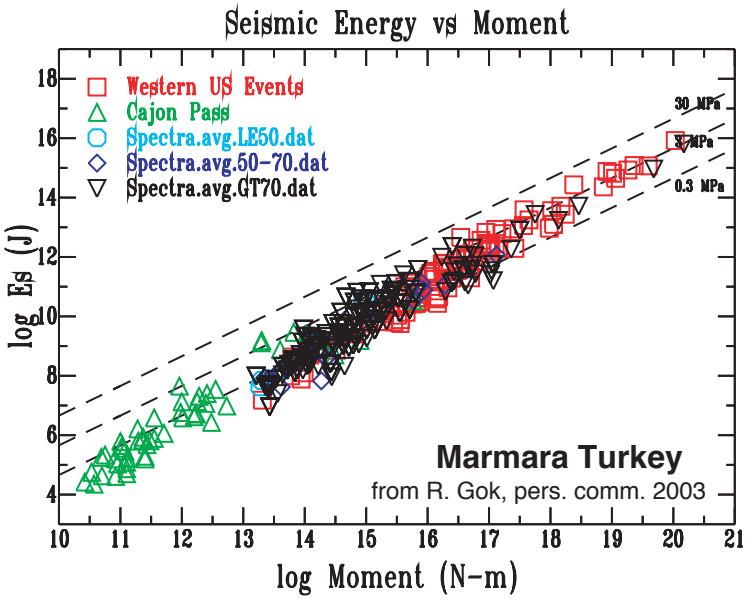

Conclusions

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The measurement of radiated seismic energy of small-to-moderate sized events is complicated by small scale-length heterogeneities and site response which are usually ignored when studying large magnitude events. An empirical approach that takes advantage of the stochastic, averaging nature of coda waves has the following advantages:

- **E_R/M_O from coda-derived moment-rate spectra provide unprecedented stability and appears to increase with increasing M_O for local and regional datasets.**
- **We do not see any biases due to censoring when we compare energy values that had larger extrapolations for both high and low frequency energy.**
- **The method yields robust spectra that are virtually free of directivity and source radiation pattern effects. This is because the coda is an azimuthal average over the focal sphere unlike direct waves that sample limited azimuths and take-off angles.**
- **We validate the long-periods of our source spectra by comparing against independent moments and apply two other constraints when correcting the higher frequencies for near-site attenuation and S-to-coda transfer function:**
  - **1) very small events are used as EGF events to derive site-response corrections for the higher frequencies (this prevents getting "f-max'd").**
  - **2) The spectral fall-off for large events should be close to omega-square.**